Technical Agency for ropeways and Guided Transport Systems (STRMTG)

Directorate General for Infrastructure, Transport and the Sea

Technical Guide

Safety in tramway driver's cab

Subject:

In accordance with the provisions laid down in the decree No. 1580 of 17/12/2010 relating to STRMTG, STRMTG produces technical guides and reference bases for the profession.

The objective of this guide is to define safety-related requirements for the design of tramway driver's cabs.

This guide applies to tramway and tram-train railway railway rolling stock which operates in an urban environment and which is covered by chapters II, III and VI of amended decree No. 2003-425 of 9th May 2003 relative to guided public transport safety.

Drafting and circulation:

The first version of the "Driver's cab ergonomics" guide (2012 version) comes from the work of a first national working group piloted by the STRMTG containing representatives of tramway operators and railway railway rolling stock manufacturers. The list of participants in this working group appears in appendix 1.

It is drafted following:

- Network observation work carried out by an ergonomic specialist on several networks,
- A summary and analysis of these observations,
- The definition of a set of specifications.

Work to draft the guide was carried out by a second national working group piloted by STRMTG containing representatives of tramway operators, railway railway rolling stock manufacturers and representatives of public authorities in charge of transport. This working group was assisted by an ergonomic specialist. The list of participants in this working group appears in appendix 2.

This update to the guide enabled the safety objectives linked to the requirements to be highlighted and enabled the document to be made more didactic than a set of specifications.

This guide is intended for all professional actors in the tramway sector (public authorities in charge of transport, project owners, operators, project managers, design offices, railway railway rolling stock manufacturers, Qualified and Registered Companies, Government inspection department).

History of updates

Version No.	*Date*	*Nature of the versions*
1	6 Feb. 2012	First version of the guide
2	10 Dec. 2012	Modification to diagram 16 area 1
3	11 June 2015	WG 2 work: separation of safety and comfort elements, change of title
3.1	25 April 2016	Translation into English

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1. Introduction and scope of the guide

1.1. Introduction

The safety of the tramway system is based mainly on the line of sight driving principle. Line of sight driving is determined in the main by the layout of the driver's cab and by the driver's high degree of visibility over their near environment, which enables them to take the right decisions at the right time.

It appeared important to provide a framework for the developments to the driver's cabs, as well as the provisions for visibility, since there was no specific reference base for tramways relating to these aspects.

This document contains the safety requirements for the design of driver's cabs. It does not replace other currently applicable regulations (in particular the Labour Code).
The requirements related to comfort are dealt with in the document published by the Union of French Operators in Public Transport and the Union of French Public Authorities in Charge of Transport "Tramway driver's cab comfort".

This document and the document published by the Union of French Operators in Public Transport and the Union of French Public Authorities in Charge of Transport come from the work produced by the two working groups mentioned above.

The safety requirements proposed in this guide constitute a working base containing the minimum allowable / tolerable provisions without justification. This identification of technical solutions constitutes the Globally At Least Equivalent references for future equipment. However, other provisions may be proposed if the equivalence of their requirement can be justified.

The document published by the Union of French Operators in Public Transport and the Union of French Public Authorities in Charge of Transport constitutes a reference base for good practice in driver's cab ergonomics on which railway railway rolling stock acquisition technical specifications may base themselves. It is intended for project owners, project managers and manufacturers.

1.2. Scope

1.2.1. Systems concerned

The requirements defined in this guide apply to all new railway rolling stock running on tramway, rail or tyres, as well as to tram-trains when they are required to travel in an urban environment in the same way as a tramway.

"New railway rolling stock" means any acquisition project which has not yet been approved at the Safety Preliminary File stage when this guide is published. For projects which have not yet been commissioned and which have already been approved at the Safety Preliminary File stage, the requirements in this guide will be taken into account where possible.

The contracts which use a framework agreement signed before the guide was published or the definition of conditional ranges of a contract signed before the guide was published will be dealt with on a case by case basis of an analysis of discrepancies with the guide (see Appendix IV Clause by Clause Grid).

Railway rolling stock on tyres which have received road accreditation is excluded from this guide.

In the case of systems required to travel in mixed mode with heavy rail convoys (see chapter VI of decree No. 2003-425) or on the national rail network (see article 46 of decree No. 2003-425), the guide's application is dealt with specifically in paragraph **6 Tram-trains**.

1.2.2. Systems in operation

No systematic conformity establishment is requested for systems in operation.

Substantial modifications to an existing system in relation to its railway rolling stock will be dealt with on a case by case basis.

If railway rolling stock is upgraded, although the guide is not applicable its requirements may be used for inspiration.

2. Driver population

Safety objective / Associated risk:

– Respecting the articular angle ranges enables all drivers to be guaranteed the correct physiological position that they may maintain for several hours and in which they may see their environment and reach the commands as required: Risk of collision or passenger accident.

The driving cab's design must be adapted to all drivers: the driver population is therefore modelled by 3 digital dummies, representing different male and female anthropometry.

All of the following requirements apply regardless of the driver's anthropometry, and so for the 3 digital dummies except where stated to the contrary.

The characteristics of these 3 dummies are defined in Appendix III. The statures of these 3 digital dummies (which shoes on) come from the machine standard NF EN 894-4 version 2010 :

- 5th percentile (small woman): de 1 560 mm in stature
- 50th percentile (medium-sized man): 1 749 mm in stature
- 95th percentile (large man): 1 911 mm in stature

The visibility requirements must be verified from the mid-point between the eyes.

A driver's cab is defined for each of these digital dummies:

- The driving chair back is tilted back 5° to 10° in relation to the vertical
- The back is in contact with the driving chair back
- The driving chair's shock absorbing is set to a medium value
- The driver is able to "pull"

The articular angles which correspond to these positions must be within the intervals defined in table 1 in relation to the reference anatomical position (see diagram 1):

Articulations	Degree of freedom	Values	Diagram
Spinal column + pelvis	Flexing / Extension	0° / 20° for a seated position with the back in contact with the seat back	2
	Left/right lateral flexing	10°/10°[1]	3
	Left/right axial rotation	10°/10° [1]	
Neck	Flexing / Extension	0° / 20° for a seated position with the back in contact with the seat back	2
	Left/right lateral flexing	10°/10°[1]	5
	Left/right axial rotation	10°/10° [1]	
Shoulders	Flexing / Extension	20° / 0°	4
		60° with full arm support	
	Abduction / Adduction	20° / 0°	
		60° with full arm support	
	Medial/lateral axial rotation	From -30° to 30° [2]	
Elbows	Flexing / Extension	80° / 120° [3]	-
Wrists	Flexing / Extension	45° / -45° [4]	6
	Abduction / Adduction (Radial/cubital deviation)	15° / -20° [4]	
Hip	Abduction / Adduction	30° / 0° [5]	-
Knee	Flexing / Extension	90° / 135° [3]	-
Ankle	Flexing / Extension	-30° / 20° [5]	7
Foot rotation	Angle between the sagittal plane and the foot's lengthwise axis	From 0° to 40° to the interior [7] From 0° to 45° to the exterior	8

Table 1: articular angles to be respected during position simulations

The flexing angles for the "spinal column and pelvis' assembly may be measured between point H on the mannequin (middle of the hips) and the point that represents the articulation between the last cervical vertebra and the first thoracic vertebra (see diagram 2). Otherwise, this last point may be taken as the middle of the shoulders (collarbone angles at 0).

The axial rotation of the "spinal column and pelvis" assembly may be measured between the axis of the hips and the axis of the shoulders (collarbone axis at 0).

The diagrams below illustrate these different articulations:

Diagram 1: Reference anatomical position (angles = 0°) [6]

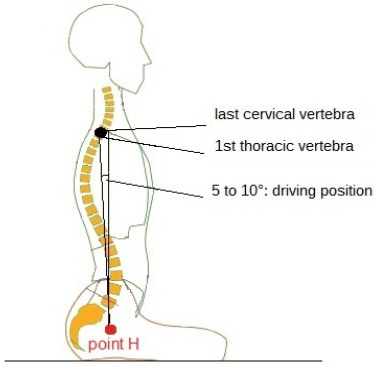

Diagram 2: flexing / extension of the pelvis + column

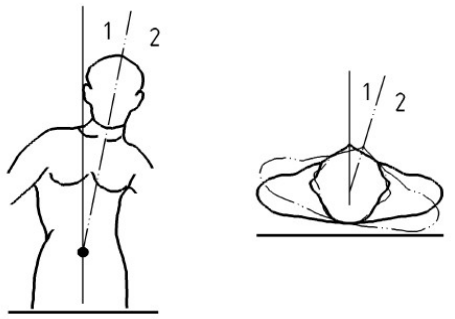

Diagram 3: Lateral and axial (twisting) flexing angles for the torso [1]

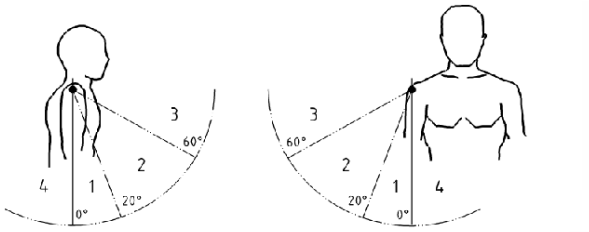

Diagram 4: Definition of the acceptable angles for the shoulder. To the left, flexing angle. In the centre, abduction angle. To the right, medial and lateral rotation angle [1]

Diagram 5: Lateral and axial (twisting) flexing angles for the neck [1]

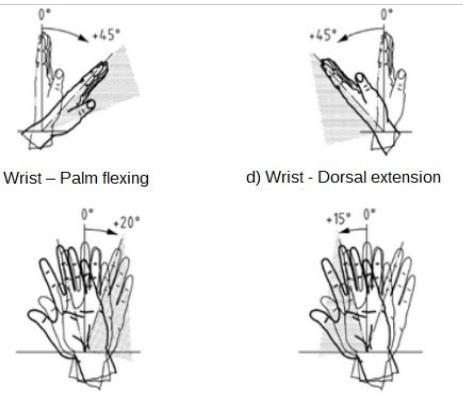

Diagram 6: Wrist angles [4]

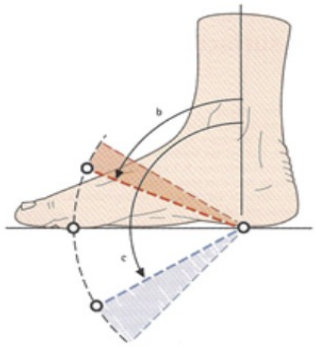

Diagram 7: Flexing extension of the ankle [5]

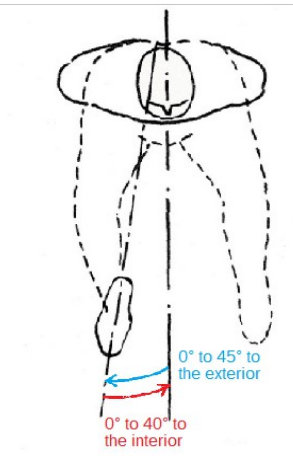

Diagram 8: Foot rotation

[1] Standard NF EN 1005-4+A1: Machine safety - Human physical performance Part 4: Position and movement when working in relation to machines
[2] Most used functional rotation according to Kapandji - Functional Anatomy - Upper limb Volume 1
[3] Rebiffé angles (1976)
[4] Standard NF EN 1005 -5+A1
[5] Kapandji - Functional Anatomy - Lower limb Volume 2
[6] Calais Germain B. - Anatomy for movement – Volume 1 – Introduction to physical technique analysis
[7] Human factors design handbook 2nd edition (Woodson W.E., Tillman B. & Tillman P.)

3. Outside field of vision

The direct visual field will be called the field of vision throughout this document.

The direct visual field represents the part of the field of vision where the driver does not need to turn their head to "see" a piece of information or signal correctly.

All the requirements apply regardless of the driver's anthropometry, and so for the 3 digital dummies.

The following requirements must be verified in a horizontal plane placed at eye height of the 3 dummies (see Appendix III digital dummies table). The visibility requirements will be verified from the mid-point between the eyes.

The requirements relative to the field of vision must be compatible with the driving chair adjustment and a tilting of the driving chair back as defined in the reference driver's cab in §2.

3.1. Far-off outside field of vision

Safety objectives / Associated risks

A good far-off outside field of vision enables the driver to anticipate in relation to the exterior environment when the tramway is moving.

– Enable all drivers to see the signals intended for them as early as possible: Collision risk.

– Enable all drivers to anticipate and detect hazard by:

– Opening their lateral field of vision taking account of the technical constraints and the physiological entry data (use of the binocular field of vision)

– limiting the hidden areas

→ Risk of collision or passenger accident.

The windscreen must enable upwards visibility of 25° in relation to the horizontal level at eye height in the sagittal plane for the 3 dummies.

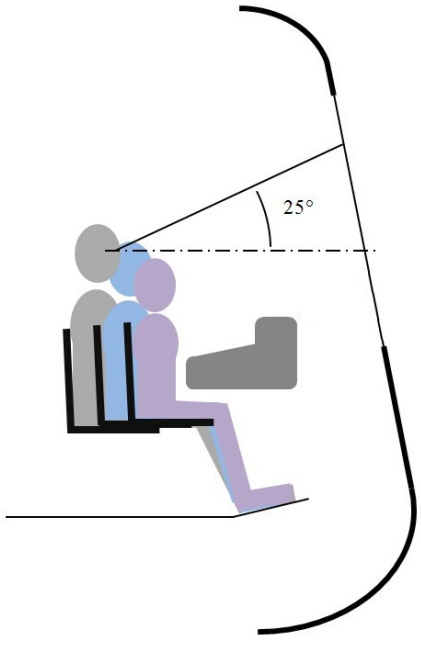

Diagram 9: Angular conditions (central driver's cab).

The end of the left and right hand visual field is a 180° angle to the front verified on a horizontal level at eye height for each of the 3 dummies.

There must be no obstacles, in particular no columns within an angle β of at least 100° (90° allowed), symmetrical in relation to the train's axis (see Diagram 10 and Diagram 11).

The masking angle α generated by the columns or any other equipment will be a maximum of 6° (6.5° allowed) from the driver's vision axis for any field of vision from 25° upwards to X° downwards in relation to the horizontal level placed at eye height inside the sagittal plane for the 3 dummies.

X° is defined as the visibility angle that enables the upper 5 cm of the cylinder defined in paragraph 3.2 to be seen by the dummy with the lowest point of view (see Diagram 14).

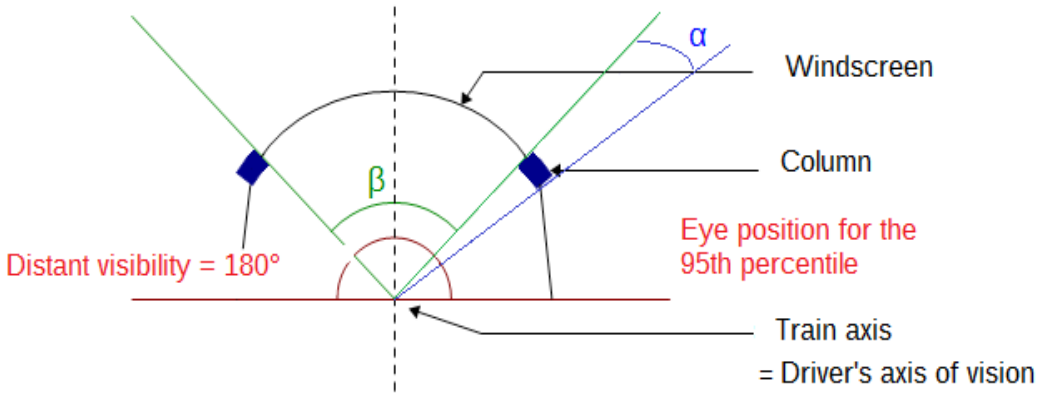

Diagram 10: Angular conditions

CASE OF OFFSET DRIVING

The driver is not centred on the train's lengthwise axis.

There must be no obstacles within a minimum angle of 25° in the direct field of view of the 3 dummies.

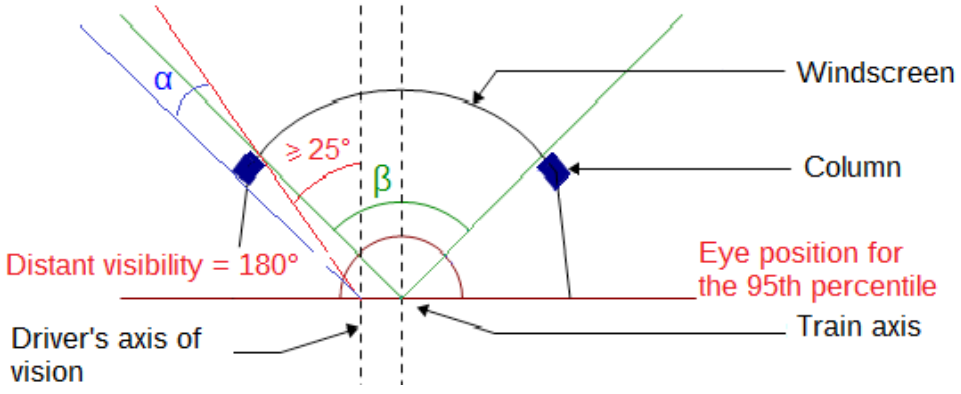

Diagram 11: Angular conditions (central driver's cab).

3.2. Close outside field of vision

Safety objectives / Associated risks:

A good close outside field of vision enables the driver to manage the restart of the tramway in relation to the exterior environment.

– Enable all drivers to detect a hazard by limiting the hidden areas: Risk of collision with a pedestrian of 6 years of age or over when the tramway starts moving in area used by pedestrians (in particular stations).

– Enable all drivers to see the signals which are intended for them: Collision risk.

A cylinder 1100 mm in height and 300 mm in diameter placed on the ground 1 metre away from the foremost surface of the tram (in relation to the edge of the cylinder), on a minimum angle of 180° centred on the cab axis must always be detected by the driver.

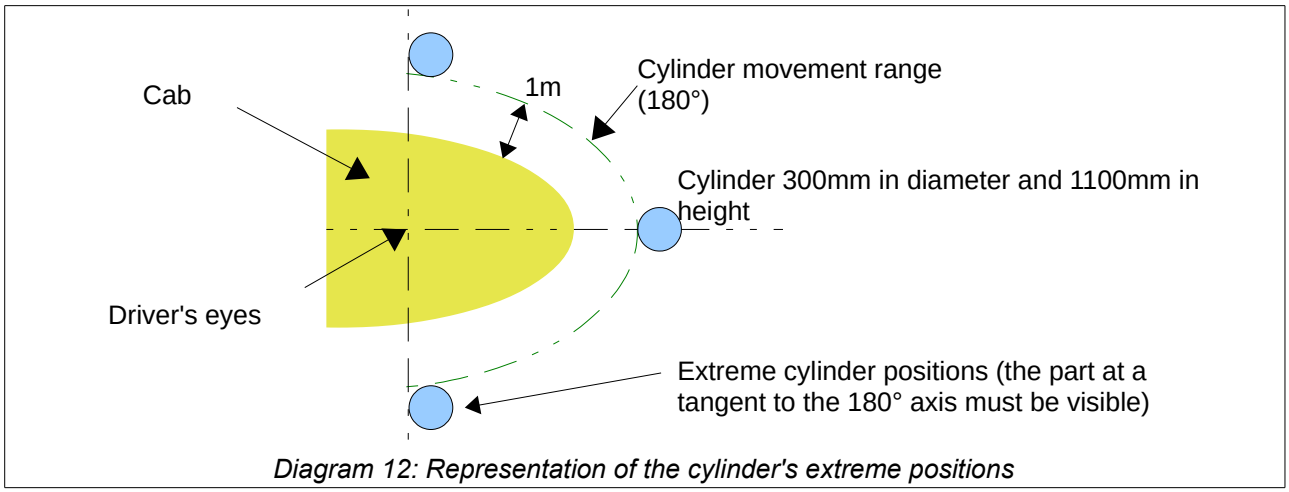

Diagram 12: Representation of the cylinder's extreme positions

To be detected, the cylinder must always be seen by the driver, at least:

- If obstructed by a pillar, at 4% of its reference surface.
  This reference surface is defined as the sum of the following surfaces projected orthogonally to the driver's direct field of vision enabling the top of the cylinder to be seen at the point located 1 m from the foremost surface of the tram (see Diagram 13) :
  - Projected front surface,
  - Projected upper surface,

  Note: in case of a pillar obstruction, we may sum up the different surfaces visible to reach the 4% as represented in Diagram 14.
- In the other masking cases, over at least the upper 5 cm of the cylinder (see Diagram 15).

This check must be carried out for the 3 dummies, setting the driving chair and tilting the back so as to achieve a driver's cab that conforms to the position in §2.

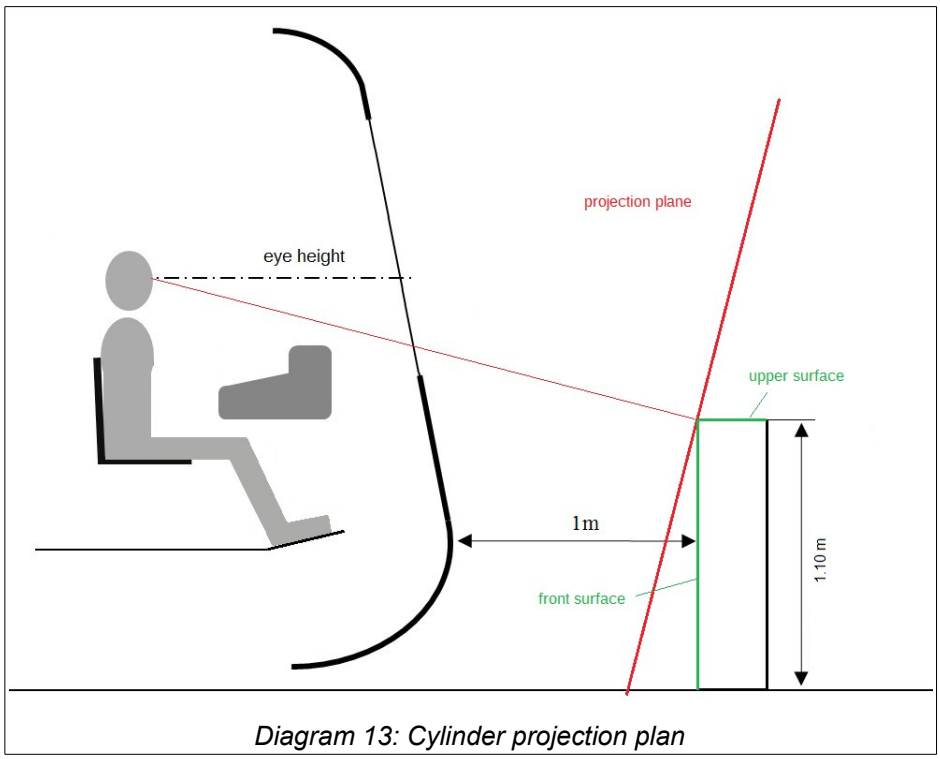

Diagram 13: Cylinder projection plan

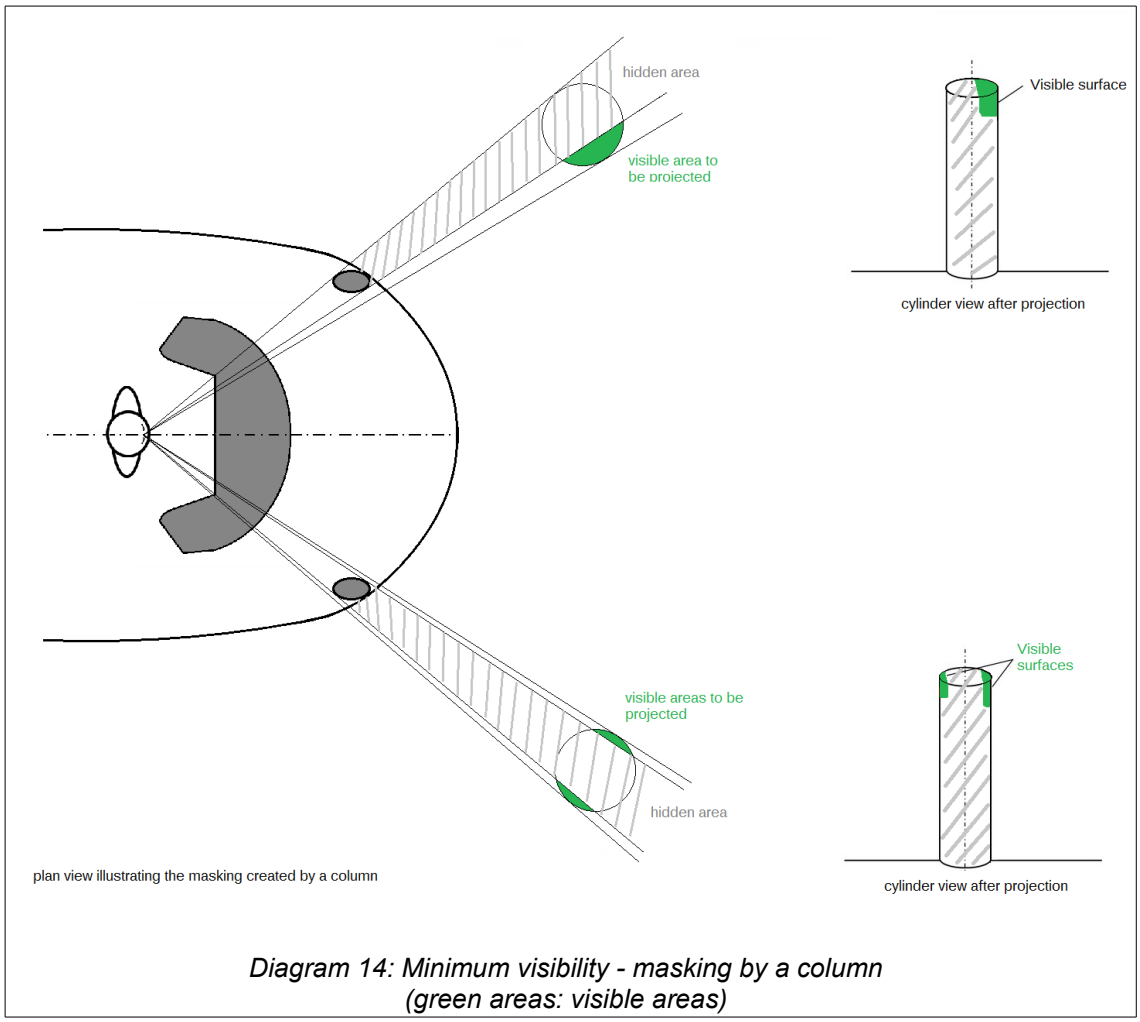

Diagram 14: Minimum visibility - masking by a column
(green areas: visible areas)

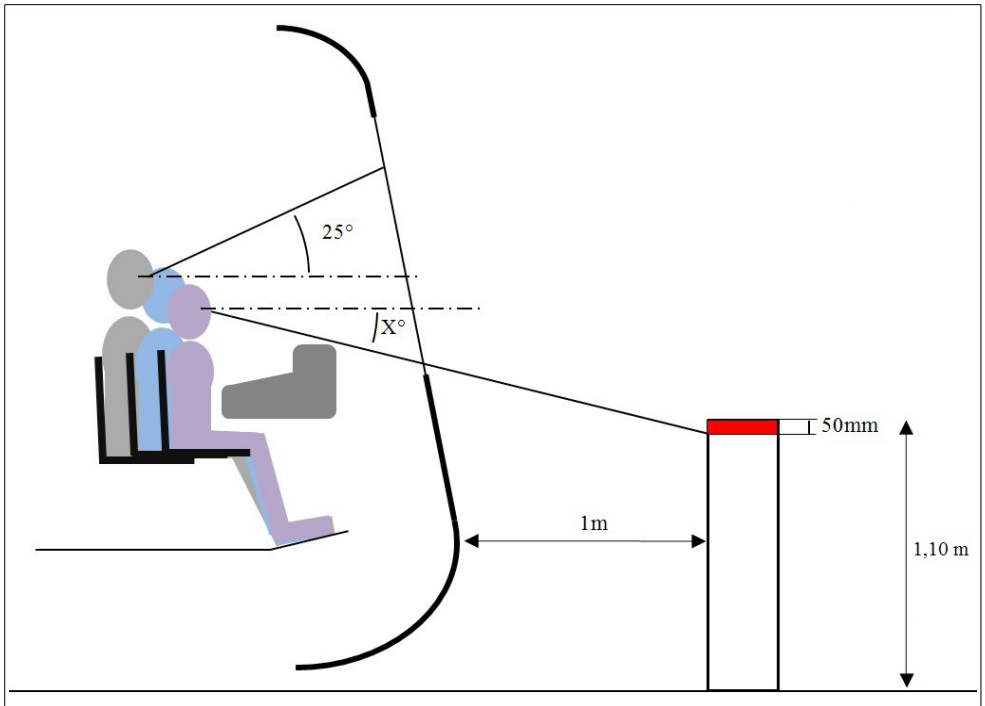

Diagram 15: Minimum visibility – other masking cases
(red area = visible area)

3.3. Passenger exchange monitoring system

Safety objectives / Associated risks:

– Enable all drivers to monitor the passenger exchange before closing the doors: risk of a passenger being jammed or a passenger falling between the platform - train or onto the platform.

– Enable all drivers to detect a passenger being dragged along as quickly as possible: Risk of a passenger being pulled along.

In the station and with straight track, the passenger exchange monitoring system must enable the detection of a 1100 mm cylinder over the full width of each door (door open); the cylinder is positioned on the platform at a maximum of 50 mm from the door threshold.

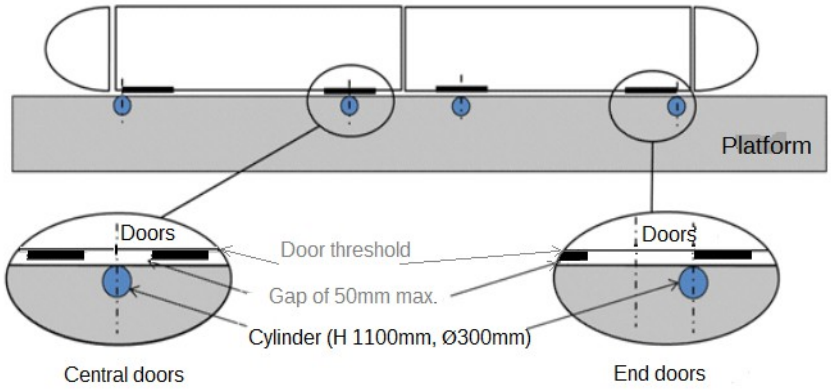

Diagram 16: Passenger exchange monitoring system

The passenger exchange monitoring system must be activated in the platform clearance area.

If this function is provided by a camera, the screens or images must enable the driver to detect effectively and comfortably any person or object around the tramway doors. They system must enable the driver to locate any people within the space easily and without confusion (image display order consistent with reality).

The passenger exchange monitoring screens' contrast and brightness must enable the details to be distinguished clearly.

The screen and camera resolution must be higher than 380 000 pixels.

4. Position constraints

4.1. Driving chair

Safety objectives / Associated risks:

– The driver must be able to evacuate quickly: risk of being imprisoned.

– The driving chair's movements must not affect the driver's visibility conditions when the tramway is moving: collision risk.

– The driving chair's design must enable all drivers to remain in a physically correct position for several hours, in which they may see their environment and reach the commands as required: Risk of collision or passenger accident.

The driving chair, including its adjustment commands, must meet the articular angle requirements defined in table 1 and the visibility requirements.

In the event of an evacuation, the driver must be able to leave their driving chair quickly and easily.

The driving chair must be stable and not be able to be incorrectly adjusted in the driving position.

The table below indicates the minimum dimensions to be respected for certain driving chair characteristics:

Characteristics	Minimum values (mm)
Seat base tilt in relation to the horizontal level	5°± 5°
Total width of the seat base surface	450
Seat base surface depth	390
Seat back tilt backwards in relation to the vertical level	From 0° to 20°
Total seat back width	475 (at the thoracic vertebrae)

Table 2: Minimum driving chair dimensions

4.2. Foot rest for hand-operated driving

Safety objectives / Associated risks

– Access to the foot commands must be guaranteed for all drivers (possible safety commands such as driver's activity control or gong): risk of collision or passenger accident following inopportune braking.

– The foot commands must be able to be easily identified by all drivers: risk of collision or passenger accident following braking.

This paragraph applies when the traction - braking command is made by hand.

If the foot rest contains foot commands such as driver's activity control, gong or emergency call:

- There must be a space on the floor beside the pedals to enable the foot to rest for the 3 dummies, in particular the 5th percentile,
- The foot commands must be validated for the 3 dummies, respecting the articular angles presented in Table 1,
- There will be enough spacing between the foot commands to prevent a single foot from activating several commands at the same time.

4.3. Foot-operated driving

Safety objectives / Associated risks:

– Access to the pedals must be guaranteed for the whole driver population: Risk of passenger accident or collision due to insufficient braking or too fast acceleration.

– The bearing force must enable a certain degree of dexterity to adjust the vehicle's acceleration and braking as much as possible: risk of collision or derailment due to excess speed, risk of passenger accident.

– The driver's foot must not slip in order to control the effort on the pedal: risk of passenger accident or collision due to insufficient braking.

– The foot commands must be able to be easily identified by all drivers: risk of collision or passenger accident following inopportune braking.

This paragraph does not deal with the foot driver's activity control actuator, which is dealt with in paragraph 4.7. This paragraph concerns the case where braking and acceleration is commanded by foot.

The use of pedals from start to end position must be validated with the 3 digital dummies.

The articular angles of the lower limbs must be within the angle intervals in table 1.

A foot rest is necessary if the 5th percentile cannot set the driver's cab so as to have their heels on the ground. In this case, the foot rest will be large enough to put two feet on it in a position that respects table 1.

The accelerator and brake pedals must be activated by the right foot.

The accelerator pedal must be placed to the right and the braking pedal to the left.

The space between them must enable one pedal to be activated without being hindered by the other.

The brake pedal's surface must be non-slip.

For the commands activated by the left foot, there will be enough space between them to prevent more than one from being activated at the same time.

The pedal's activation force will be measured at the place where the front of the foot of most drivers presses the pedal (front part of the metatarsal).

The bearing force for the accelerator must be between 25 N and 40 N (recommended 30 / 35 N). To brake in normal service braking (< 1.2 m/s²), the bearing force to be applied by the driver must be between 20 and 100 N.
The bearing force necessary to reach a full service braking or emergency braking must not exceed 250 N.

4.4. Master controller

Safety objectives / Associated risks:

– Provider all drivers with a high level of dexterity for the master controller to adjust acceleration and braking: risk of collision or passenger accident.

– Enable all driver to manage accurately their master controller's range, in particular if it is in emergency braking or full service braking position: risk of collision following insufficient braking.

– If the driver loses consciousness, do not remain in traction: risk of collision.

The master controller must be in a location close to the segment reach capacities and the articular limits (shoulder, elbow, wrist) to limit the effects and constraints (see Appendix III and table 1).

A surface at the right height must enable the driver to place their forearm while activating the master controller, whose position and movement are in continuity with the arm's natural movement, i.e. they respect the angles defined in table 1 and verified for the 3 digital dummies.

The master controller's dimensions must enable it to be gripped by all drivers.

There must be notches between neutral and traction, neutral and braking and change to emergency braking.

When the master controller is released in traction it returns to neutral at least.

The maximum activation torque for the rotating master controller is 0.5 N.m outside the notches.

The master controller's linear movement force is 11 N maximum outside the notches.

4.5. Interior field of vision

Safety objectives / Associated risks:

– Enable all drivers to detect an incident in the passenger space (alarm and passenger emergency call alarm): Risk of passenger accident.

– Enable all drivers to estimate their speed in relation to the technical and environmental constraints: Risk of derailment due to excess speed or collision.

– Enable all drivers to detect a technical problem on the vehicle requiring their immediate action: Risk of collision following a vehicle failure or a fire.

– Enable all drivers to access the information as quickly as possible without moving their heads, limiting the time when the driver looks away from their exterior environment: Collision risk.

The interior field of vision is the field of vision while moving that enables information to be provided to drivers. This information is the following:

- Tachometer,

- Passenger emergency alarm,

- Passenger emergency call alarm,

- Reporting of defaults (this may be a reminder via pictograms positioned in the field of vision defined below).

This information is located in the vertical plane, between 20° above the horizontal level at eye height and 30° below (40° allowed).

In the horizontal plane, this information must be within the area at 35° from the axis of vision (50° allowed).

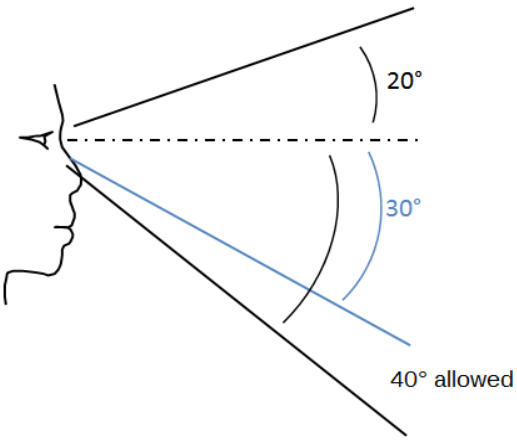

Diagram17: Field of vision, vertical plane

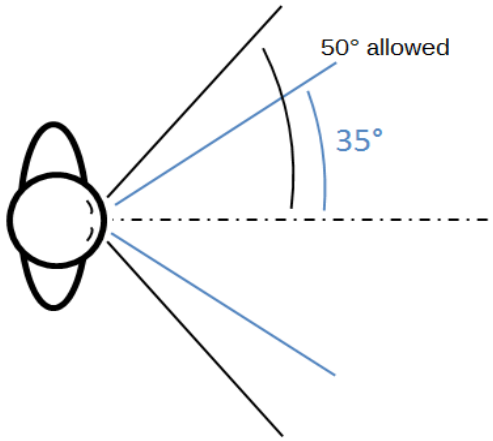

Diagram18: Field of vision, horizontal plane

The surface plane of the upper part of the driver console must form an angle that is compatible with the screen's oblique visibility tolerances defined by its supplier for all the dummies.

For displays that emit light, the contrast ratio (ratio of the front surface's brightness to the rear surface's brightness) must be at least 3.1 to satisfy this requirement; a ratio of 6:1 is recommended.

4.6. Commands

Safety objectives / Associated risks:

– Enable all drivers to activate the necessary command as quickly as possible: risk of collision or derailment (no gong, dazzling of the driver, switch command, etc.).

– A certain number of commands, in particular those to inhibit the safety function monitoring mechanisms (driver's activity control, doors, etc.) must not be activated by mistake: risk of collision or passengers falling onto the track.

The commands must be laid out according to the driver's driving activity, their effect/impact on safety and according to their usage frequency (for example, two functions that may be used at the same time must not require the arms to be crossed over).

– A command must not necessarily be visible but must be easily and quickly located then reached by the driver intuitively. The commands that are reached intuitively may be the gong, the horn, the driver's activity control, the hazard warning signal and the security brake.

– A command which is rarely used but which has a safety-related function must be placed in the close-reach area and must be easily identified visually during the day and at night.

All pedals must be placed opposite the foot which is to activate it at an angle that respects table 1.

Three areas are identified for the command position:

Accessibility areas	Description of the actions to be performed by the driver in the area in question
1	This area contains the commands used both while moving and when stopped. For the commands in area 1, the driver is in seated position with the driving chair back tilted backwards by 5 to 10°, is looking straight ahead and may have one hand placed on the master controller. The commands in this area must be able to be reached simply by moving the arm but without moving the trunk in relation to the reference driver's cab (see §2).
2	Sometimes during a journey the drivers activates a command from their driving chair. In addition to their arm, they may move their trunk to a maximum of 15°, either with flexing in the sagittal plane (profile) or with lateral flexing (see Diagram 3 left hand side) to reach the commands in this area.
3	The driver activates a command infrequently and which they may be required to get up from their driving chair to access.

The commands in areas 1 and 2 are forward of point H in the 3 dummies' driver's cab (the most restrictive case: 5th percentile).

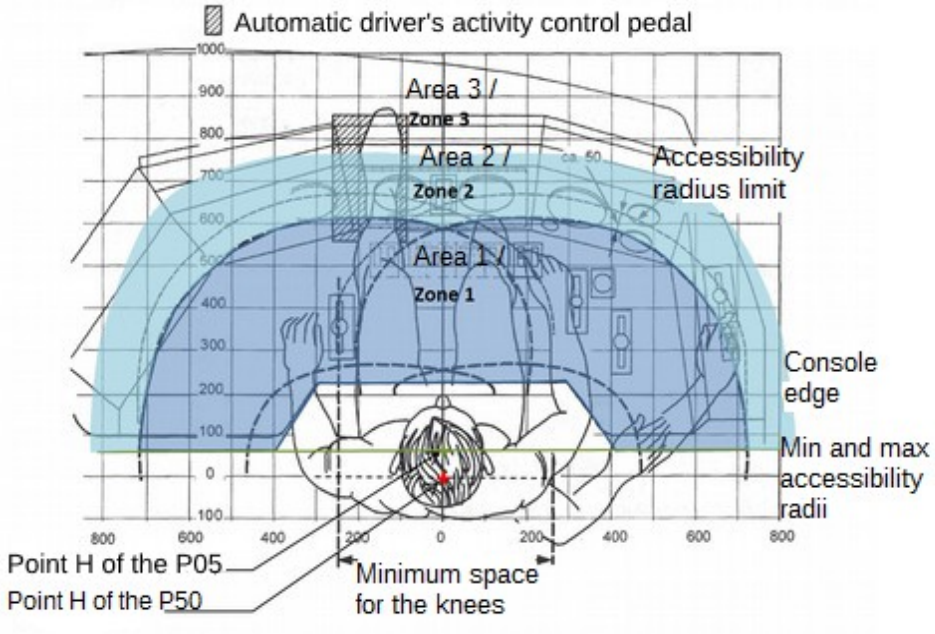

Diagram19: Indication of the areas for command position
Diagram based on UIC 561 appendix 1

These areas are represented in Diagram 19. The definition of the areas by the digital dummy reach casings may also be used (3-dimensional approach.

The following commands will be lead-sealed: driver's activity control shunt, bogie isolation and reverse.

For the commands with a safety-related function, these must be positioned in the areas indicated below.

The position represents the minimum that may be required: a "area 2" command may be moved to a more restrictive area (area 1). Combining several commands leads the selected commands to be positioned in the most restrictive area.

The following list is not intended to be exhaustive or to impose the functions listed.

According to certain line configurations, the safety analysis may redefine the area that constitutes the minimum that may be demanded.

AREA 1 MAIN FUNCTIONS

Commands used while moving:

- Railway railway rolling stock alarm acknowledgement (alarm indicated on the console)
- Alarm handle acknowledgement
- Switch command
- Passenger exchange monitoring system activation command
- Emergency braking disengagement (if Emergency braking revocable)
- Windscreen wiper / Windscreen washer / De-icer
- Gong / horn
- Security brake
- Passenger emergency call alarm (announcements and communication following passenger request)
- Master controller
- Magnetic track brake
- Traffic control office voice communication (activation command, radio handset if push to talk possible with hands free)
- Emergency call command
- Sanding
- Inter-cab ringer and voice communication activation command (if towing-pushing)
- Driver's activity control if manual command

Commands used when stopped:

- Fog light (rear)
- Command to change viewing area by the passenger exchange monitoring system (platform area or sides of the vehicle)
- Energy input mode change (pantograph, battery, ground level power supply-APS), etc.)
- Passenger door commands (side selection, opening, closing, etc.)
- Dipped lights - main beam lights switching
- Hazard warning signal

AREA 2 MAIN FUNCTIONS

- Sun-shield command (if electric)

AREA 3 MAIN FUNCTIONS

- Lower the pantograph

4.7. Driver's activity control actuator

Safety objectives / Associated risks:

– Detect the loss of consciousness of the driver: risk of enclosure (passenger panic) or collision / derailment due to excess speed following an inopportune movement of the train.

– The driver's activity control actuator must be accessible to all drivers: Risk of passenger accident following standby non-acknowledgement braking.

A system to stop the train if the driver loses consciousness must be present.

The reach and operation of this system must be validated by simulation using the 3 digital dummies in "driver's activity control acknowledged" position and respecting the angles defined in table 1.

The system's manual activators must be placed in area 1 defined in the 4.6 Commands chapter. For foot activators, there must be enough space between the pedals to prevent several pedals being activated by the same foot simultaneously.

The driver's activity control activator must not be able to be held in acknowledged position other than by a conscious driver (for example, the following are not acceptable: hand falling onto a button enabling the driver's activity control to be acknowledged or the leg's own weight holding the driver's activity control pedal in acknowledged position).

Standby with repeated foot pressure is not compatible with foot-operated driving.

5. Driving cab environment

The requirements must be checked for the whole driver population in keeping with the possible driving chair adjustments.

5.1. Windscreen and side windows

Safety objective / Associated risk:

– Enable all drivers to have a high degree of visibility of the obstacles and signals while guaranteeing the absence of any major deformation of and confusion between colours: risk of collision.

The photometric characteristics and the quality of vision for the windscreen and the side window which cover the outside field of vision must conform to the specifications in paragraphs 10.3.1 "Light transmission factor", 10.3.2 "Diffusion" and 10.4 "Vision quality" in standard NF F 15-818 "Railway rolling stock – Front windows".

The windscreen must not modify the perception of the colour of the signals for tramway drivers, or the colour of the road signals, especially if the windscreen is tinted. The fact that the perception of the signals is not altered shall be checked according to the conditions specified in appendix B of NF F 15-818 or any other equivalent evaluation method.

The side windows that cover the outside field of vision must not modify either the perception of the colour of the signals for tramway drivers or the colour of the road signals.

The glass surfaces located within the 180° field of vision to the front (windscreen and side windows) must be equipped with effective de-icing and de-misting systems.

The demist systems must not create any image distortion when operating. The absence of distortion may be checked by viewing a landscape in daylight within the outside field of vision area.

The demist systems must cover at least the windscreen wiper sweeping area as defined in the following paragraph.

They must also cover at least 80% if the surface of the side windows over the height between X° under the horizontal plane at eye height and 20° above (with X° as defined in paragraph 3.1).

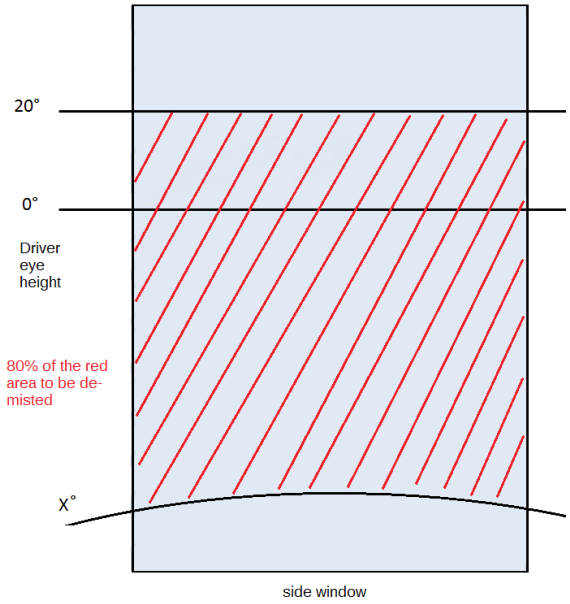

Diagram20: Minimum surface to be de-misted (side windows)

5.2. Windscreen wipers

Safety objectives / Associated risks:

– Enable all drivers to have a high degree of visibility of the obstacles and signals while guaranteeing the absence of any hindrance by the windscreen wiper brushes: risk of collision.

– Enable all drivers to see regardless of the exterior weather conditions (cold, dampness, low sun): risk of collision.

The following requirements must be met for the 3 digital dummies.

The windscreen wiper(s) must cover at least 95 % of the area represented on the diagrams 21 and 22 defined as the sum of the following surfaces:

- In the upper part on the horizontal plane at eye height, a triangular surface whose peak is on the axis of the train at least 20° upwards and whose other points are at least 40° (35° allowed) on each side of the train axis.
- In the lower part on the horizontal plane placed at eye height, a surface centred on the train's axis, which covers at least 40° (35° allowed) horizontally on each side of the train's axis and at X° downwards.

X° is defined as the visibility angle that enables the upper 5 cm of the cylinder defined in paragraph 3.2 to be seen by the dummy with the lowest point of view.

The diagram 21 represents a central driver's cab. In the case of an offset driver's cab, the area represented on the diagram will be offset according to the location of the axis of vision(see diagram 22).

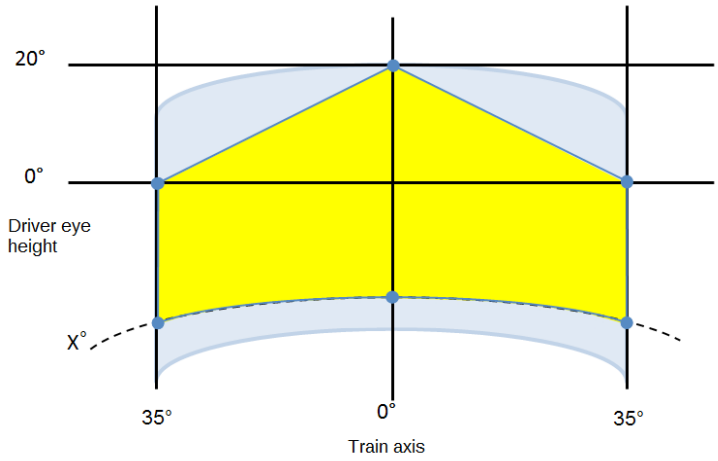

Diagram21: Minimum surface to be covered by the windscreen wipers in centred driving (in yellow)

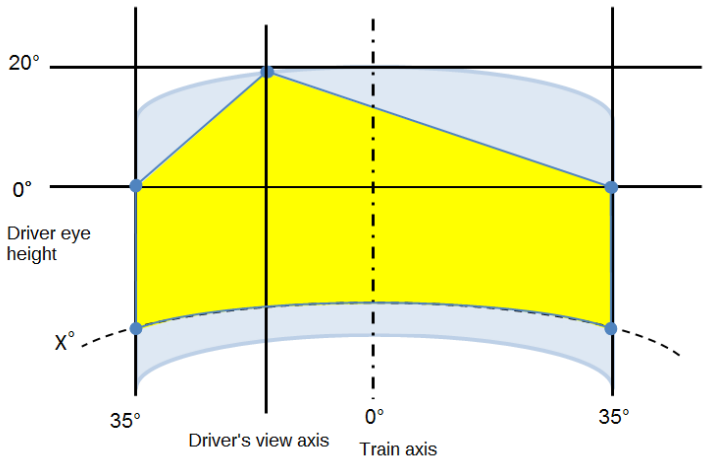

Diagram22: Minimum surface to be covered by the windscreen wipers in offset to the left driving (in yellow)

The windscreen wiper(s) must have variable speeds.

At rest, the brushes must be positioned outside the sweeping area or at the limits.

The width of the windscreen wiper arms must be limited to avoid masking visibility.

5.3. Solar protection

Safety objectives / Associated risks:

– Enable all drivers to have a high degree of visibility of the obstacles and signals while guaranteeing the absence of any major deformation of and confusion between colours: risk of collision.

– Enable all drivers to see regardless of the exterior weather conditions (cold, dampness, low sun): risk of collision.

Solar protections (for example sun-shield, tinted or coated windows) must be available for the windscreen and the side windows within the 180° field of vision to the front. These mechanisms must not modify either the perception of the colour of the signals for tramway drivers or the colour of the road signals.

The area covered by the eyes of the 3 digital dummies in driver's cab must be protected from direct sunlight to avoid the drivers being dazzled.

In the case of adjustable solar protection mechanisms, adjustments must be able to be made by the operator with simple movements to deploy or raise them.

5.4. Alarm signals

Safety objective / Associated risk:

– Enable the driver to identity quickly a sound alarm that requires immediate action by them: risk of collision or passenger accident or fire.

The sound signals concerned are, for example, the anomaly alarms, the driver's activity control system fault and the door closure.

The alarm signals' acoustic pressure level must exceed the ambient noise level of at least 5 dB, without exceeding it by more than 10 dB.

The signal/noise ratio is not the only factor to be taken into consideration. Human hearing sensitivity is related to frequency. It is more sensitive to signals within the 500 Hz to 3000 Hz domain. So the dominant frequencies of the signalling system must be within this range and must differ from the dominant frequencies from any noise.

Audible signal quality must respect the requirements in §4.3 in standard NF EN 981-A1 (2008) "Machine safety - Audible and visual hazard and information signal system".

The audible alert signals must be consistent with the visual alert signals in accordance with standard NF EN 981-A1.

5.5. Lighting/illumination

Safety objective / Associated risk:

– All risk of dazzling (cab and passenger space interior lighting) or hindrance to visibility (reflections on the windscreen, flickering of the lighting) the driver must be controlled: risk of collision.

The passenger area and the inside of the cab must not reflect onto the windscreen.

The cab lighting's light source must not be within the driver's field of vision.

The cab lighting must respect the requirements in standard NF EN 13,272 (2012) "Electric lighting for public transport railway railway rolling stock equipment".

6. Tram-trains

The railway railway rolling stock to which this chapter applies is the railway railway rolling stock required to travel in urban environments, as well as in mixed environments with heavy rail convoys or on the national rail network.

The whole of the guide applies to tram-trains, except for the following paragraphs:

- 3.1 Far-off outside field of vision
- 3.2 Close outside field of vision
- 4.5 Interior field of vision
- 4.6 Commands
- 5.2 Windscreen wipers

These paragraphs are adapted as follows to take account of the specifics that apply to the tram-trains (collision scenarios and higher number of commands in particular).

In addition, **all the requirements which apply to tram-trains (whether or not they are adapted) must be checked**, not with the 3 digital dummies indicated in appendix III, but **with the 2 dummies defined in UIC 651** then, once it is applicable, with the dummies defined in **standard NF EN 16 186-1**. The reference driver's cab defined in §2 is unchanged.

6.1. Far-off outside field of vision

The windscreen must enable upwards visibility of 25° in relation to the horizontal level at eye height in the sagittal plane for all the dummies.

Theend of the left and right hand visual field is a 180° angle to the front verified on a horizontal level at eye height for each of the dummies.

There must be no obstacles, in particular no columns, within an angle β of at least 100° (90° allowed), symmetrical in relation to the train's axis (see Diagram 10: Angular conditions).

The masking angle α generated by the columns or any other equipment will be a maximum of 8.5° [1] for any field of vision from 25° upwards to X° downwards in relation to the horizontal level placed at eye height in the sagittal plane for all the dummies.

X° is defined as the visibility angle that enables the upper 5 cm of the cylinder defined in paragraph 3.2 to be seen by the dummy with the lowest point of view (see Diagram 15).

1 These masking angles are modified to take account of the requirements in regulations on passive tram-train safety (collision scenario harsher than for tramways).

If a system exists to enable indirect visibility of the cylinder, X° is defined as the maximum angle of visibility downwards for the dummy with the lowest point of view.

In the case of an offset driver's cab (driver not centred on the train's lengthwise axis), there must not be any obstacles within a minimum angle of 25° in the dummies' vision axis (see Diagram 11: Angular conditions (central driver's cab).).

6.2. Close outside field of vision

Due to a higher number of commands to be integrated into the console (impact on the console depth), the visibility criterion related to the cylinder is adapted as follows.

The following requirements must be checked for all the dummies, setting the driving chair and tilting the back so as to achieve a driver's cab that conforms to the position in §2.

A cylinder 1100 mm in height and 300 mm in diameter placed on the ground 1 metre away from the foremost surface of the tram (in relation to the edge of the cylinder), on a minimum angle of 180° centred on the cab axis (see Diagram 12) must always be detected by the driver.

To be detected, the cylinder must always be seen by the driver, at least:

- if obstructed by a pillar, at 4% of its reference surface.
  This reference surface is defined as the sum of the following surfaces projected orthogonally to the driver's direct field of vision enabling the top of the cylinder to be seen at the point located 1 m from the foremost surface of the tram (see Diagram 13) :
  - projected front surface,
  - projected upper surface,

  Note: if masked by the columns, we may sum up the different surfaces visible to reach the 4% as represented in Diagram 14.
- in the other masking cases, over at least the upper 5 cm of the cylinder (see Diagram 15).

If this criterion cannot be achieved, a system that enables its indirect visibility is accepted.

6.3. Interior field of vision

Due to a higher number of commands to be integrated into the console, the tachometer, passenger emergency alarm, passenger emergency call alarm and reporting of defaults information layout is redefined as follows:

- Vertical plane: between 20° above the horizontal plane at eye height and 35° below (50° allowed, see Diagram 23)
- Horizontal plane: located in the area at 35° of the vision axis (50° allowed, see Diagram 18)

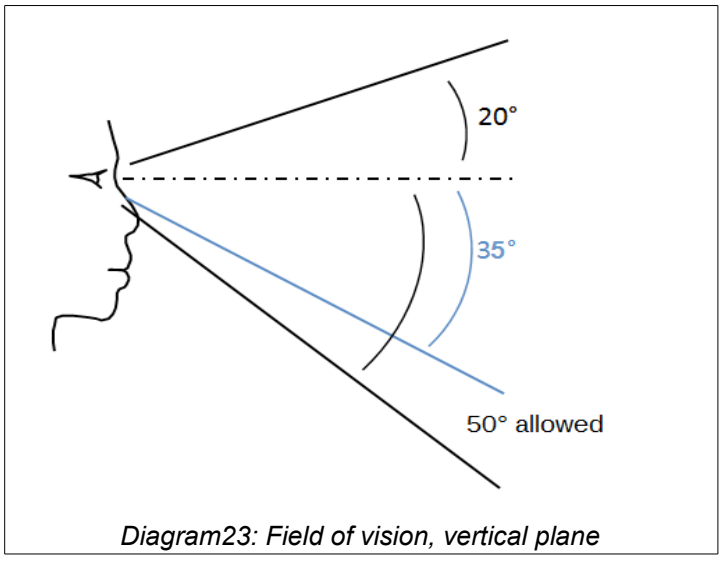

Diagram23: Field of vision, vertical plane

The surface plane of the upper part of the driver console must form an angle that is compatible with the screen's oblique visibility tolerances defined by its supplier for all the dummies.

For displays that emit light, the contrast ratio (ratio of the front surface's brightness to the rear surface's brightness) must be at least 3.1 to satisfy this requirement; a ratio of 6:1 is recommended.

6.4. Commands

Due to a higher number of commands to be integrated into the console, the requirements relating to the commands are adapted.

The area definitions in §4.6 Commands are unchanged.

The commands must be laid out according to the driver's driving activity, their effect/impact on safety and according to their usage frequency (for example, two functions that may be used at the same time must not require the arms to be crossed over) :

– A command must not necessarily be visible but must be easily and quickly located then reached by the driver intuitively. The commands that are reached intuitively may be the gong, the horn, the driver's activity control, the hazard warning signal and the security brake.

– A command which is rarely used but which has a safety-related function must be placed in the close-reach area and must be easily identified visually during the day and at night.

All pedals must be placed opposite the foot which is to activate it at an angle that respects table 1.

The commands in areas 1 and 2 are forward of point H in the dummies' driver's cab (the most restrictive case: 5th percentile).

The following commands will be lead-sealed: driver's activity control shunt, bogie isolation and reverse.

For the commands with a safety-related function, these must be positioned in the areas indicated below.

The position represents the minimum that may be required: a "area 2" command may be moved to a more restrictive area (area 1). Combining several commands leads the selected commands to be positioned in the most restrictive area.

The following list is not intended to be exhaustive or to impose the functions listed.

According to certain line configurations, the safety analysis may redefine the area that constitutes the minimum that may be demanded.

AREA 1 MAIN FUNCTIONS

Commands used while moving:

- rolling stock alarm acknowledgement (alarm indicated on the console)
- Alarm handle acknowledgement
- Switch command
- disengaging of emergency braking (if reversible emergency braking)
- Gong / horn
- Security brake
- Master controller
- Magnetic track brake
- Sanding
- Driver's activity control if manual command

Commands used when stopped:

- Fog light (rear)
- Command to change viewing area by the passenger exchange monitoring system (platform area or sides of the vehicle)
- Energy input mode change (pantograph, battery, ground level power supply-APS, etc.)
- Passenger door commands (side selection, opening, closing, etc.)

- Dipped lights - main beam lights switching
- Hazard warning signal

AREA 2 MAIN FUNCTIONS

- Sun-shield command (if electric)
- Passenger exchange monitoring system activation commands
- Windscreen wiper / Windscreen washer / De-icer
- Passenger emergency call alarm (announcements and communication following passenger request)
- Traffic control office voice communication (activation command, radio handset if push to talk possible with hands free)
- Emergency call command
- Inter-cab ringer and voice communication activation command (if towing-pushing)

AREA 3 MAIN FUNCTIONS

- Lower the pantograph

6.5. Windscreen wipers

The paragraph 5.2 "Windscreen wipers" is adapted as follows.

The requirements must be respected for the whole driver population in keeping with the possible driving chair adjustments.

The windscreen wiper(s) must cover at least 95 % of the area represented on the diagrams 21 and 22 defined as the sum of the following surfaces:

- In the upper part on the horizontal plane at eye height, a triangular surface whose peak is on the axis of the train at least 20° upwards and whose other points are at least 40° (35° allowed) on each side of the train axis.
- In the lower part on the horizontal plane placed at eye height, a surface centred on the train's axis, which covers at least 40° (35° allowed) horizontally on each side of the train's axis and at X° downwards.

X° is defined as the visibility angle that enables the upper 5 cm of the cylinder defined in paragraph 3.2 to be seen by the dummy with the lowest point of view.

If a system exists to enable indirect visibility of the cylinder, X° is defined as the maximum angle of visibility downwards for the dummy with the lowest point of view.

The windscreen wiper(s) must have variable speeds.

At rest, the brushes must be positioned outside the sweeping area or at the limits.

The width of the windscreen wiper arms must be limited to avoid masking visibility.

7. APPENDIX I: Participants in the 1st working group

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BELLON	Christophe	CAF / CFD
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BODIN	Nicolas	Transvilles
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BRUAND	Hervé	SEMITAN
CHOKOMERT	Philippe	UTP
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DEMMERLE	Eliane	TRANSAMO
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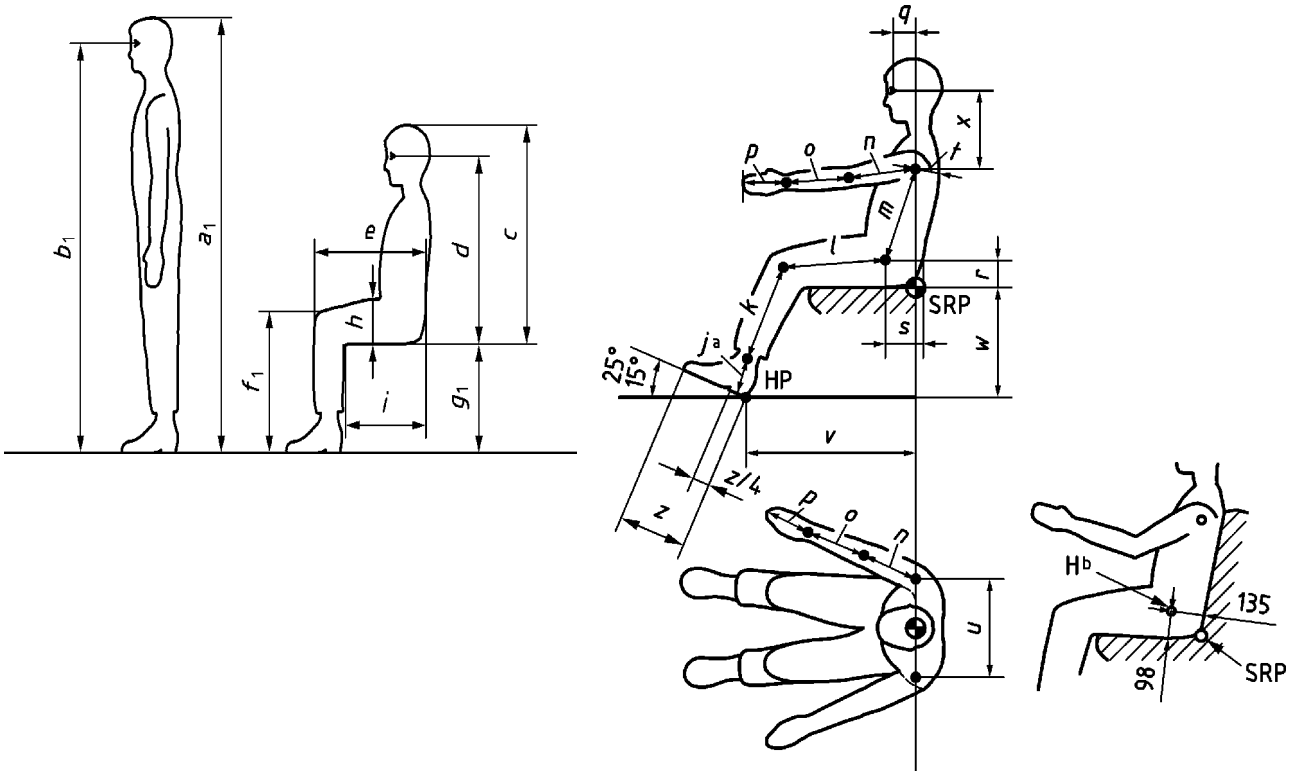
HOLSTEIN Sébastien	TRANSDEV	THERY Emmanuel	SNCF / CIM
LABASQUE Damien	ALSTOM	THEVENET Jean-Philippe	BOMBARDIER

9. APPENDIX III: Definition of the 3 digital dummies



	anthropometry of the 3 dummies in standard NF EN 894-4								
	a1[a]	*b1*[a]	*c*	*d*	*e*	*f1*[a]	*g1*[a]	*h*	*i*
P5	1 560	1 450	790	680	543	490	370	112	430
P50	1749	1633	906	790	604	560	444	146	499
P95	1 911	1 780	991	860	664	632	535	170	560

a1: anthrompometric dimensions comprising the shoes (30 mm)

	inter-articular dimensions given for information purposes													
	ja	*k*	*l*	*m*	*n*	*o*	*p*	*q*	*r*	*s*	*t*	*u*	*x*	*z*
P5	104	334	378	392	255	222	167	75	68	105	97	272	227	217
P50	114	393	426	457	286	246	196	84	88	113	118	342	248	250
P95	125	453	473	498	308	263	217	91	101	118	131	387	261	285

10. APPENDIX IV: Clause by clause grid

The technical guides

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